

Head-Tracker Table

Mfg/Product	Type	Static Accuracy	Resolution	Wires to pilot	Lag/Rate	Cost
3 rd Tech HiBall	6DOF Optical (required fixed external LED grid)	Abs. Accuracy 0.5mm RMS, 0.03deg RMS	Resolution 0.2mm, 0.03deg	Ethernet, Serial	<1ms Latency	\$25,000
Ascension PcBird (FlockofBirds on a PC card) (Helicopter Flight History)	6DOF Pulsed DC Magnetic	0.07" RMS 0.5° RMS	Static Resolution 0.02" RMS 0.1° RMS	RS-232C	7ms	\$2475
Ascension MiniBird	6DOF Magnetic	Static Accuracy: 0.07" RMS, 0.5° RMS	Static Resolution: 0.02"RMS, 0.1° RMS	RS-232C	8ms	\$3996
Ascension LaserBird (now in beta-testing, available Summer 2001)	6DOF Optical (Scanner/ Receiver FOV: \pm 50° horizontal \pm 60° vertical)	1.0mm RMS (quoted figures. Actual performance expected to be better than PcBird)	0.1mm RMS	RS-232 RMS	5.7ms	\$17,000
DynaSight Optical Tracker	6DOF Optical IR 75degx75deg receiver field of regard	2mm cross range, 8mm down range	Res 0.1mm crossrange 0.4mm down range	Dual RS-232C Through DB9	9-28ms Operating mode dependent	\$2495 (\$2195 w/o dev kit)
Isense InterTrax	3DOF Inertial	Max/Min rate: 3deg/720deg	Angular Resolution 0.02deg relative	Serial RS-232 Or USB	4ms	\$1000
Polhemus Fastrak (has flight history)	6DOF Magnetic	0.03" RMS position, 0.15 orientation	Resolution: 0.0002"/in. sep from receiver, 0.025 orientation.	RS-232 (opt 422)	4ms	\$6050
Polhemus Isotrak	6DOF Magnetic	Static Accuracy: 0.1" RMS, 0.75deg	Resolution 0.0015"/in. separation, 0.1°	RS-232C	20ms	\$2875
Shooting Star ADL-1	6DOF Mechanical (Potentiometers)	0.2" accuracy	0.1" repeatability	DB9 RS-232C	<2ms	\$1495
WW Gaertner / GEC- Marconi GRD-1000	6DOF IR	30 arcseconds (within 2-3 feet of IR LEDs)	0.3°		1-4ms (250Hz- 2400Hz)	\$20,000 (1993)

Obstacle Sensor Table

Mfg/Product	Type	Cost	Coverage	Availability	Accuracy	Resolution
Survair (Helicopter flight history)	LIDAR database generator	\$250k	(Claim full terrain coverage at high flight speed)	Now	10cm to global coordinates	
Amphitech OASys	Milimeter Wave Obstacle Radar	\$135k	Angular Range +/- 90deg Azimuth, +30/-80 deg in elevation. Scan rate up to 120 deg/sec	Now	Stabilization up to 30 deg combined pitch and roll with 0.1 degree accuracy. Range resolution better than 5m	Reported wire detection at 1 nmi.
BAE Terprom	Hybrid EGPWS with database and scanning laser	\$80-\$100k		EGPWS is currently flown on Eurofighter – Typhoon and USAF C-17. Hybrid is not yet available		Hope to achieve detection of 3mm wire at 500m. Uses the database to alert for Big distant threats and the lidar for proximate small obstacles
APHS (Apache Longbow Flown)	FLIR, image intensifier fusion	?	1600x960 display image	Now		“Pilots were easily able to discern terrain features and to distinguish telephone poles and wire obstacles”

Attitude Sensor Table

Mfg	Product	Position Accuracy	Dynamic Attitude Accuracy	Attitude Data Rate	Size/Wt/Pwr	Availability	Cost
Litton	LN-200	Raw Sensor Output	Raw Sensor Output	Raw data latency < 1 msec	Size - 3.5 inches (8.9cm) diameter by 3.35 inches (8.5 cm high) Weight - 1.54 pounds (700 grams) Power 10 watts steady-state (nominal)		~\$15k
LITEF	LCR 92/93	N/A	Pitch/Roll +/- 1 Heading +/- 2	64 Hz	11"x5.0"x4.1" 6 lb., 25 W max at 28 VDC	90-120 days	~\$30k
Seagull	GIA-2000	N/A	Pitch/Roll +/- 1.5 Heading +/- 2	50Hz	9.25"x5.7"x5" 5 lb., 12 W max at 14 or 28VDC	Prototypes in development.	~\$15k
Crossbow	AHRS 400 CA	N/A	Pitch/Roll +/- 2 Heading +/- 3	> 60 Hz	3"x3.75"x4.1" < 1.4 lb., < 4W at 9-30 VDC	2-4 weeks	\$7,500
Watson	AHRS-E304	N/A	Pitch/Roll +/- 0.3 static Heading +/- 2 static	50 Hz	5.78"x4.68"x3.24" 2 lb., ~6W at 12 VDC	2 weeks	\$10,966

Position Sensor Table

Structure	Product	Position Accuracy	Data Rate (Pos & Vel)	Size/Wt/Pwr	Availability	Cost
WAAS	Yet to be released. Many aviation GPS receivers are WAAS upgradeable	7m vertical 95% of the time	1 Hz standard although some may decide to support higher rates			~\$15k
LAAS	Not yet available	5m 95% of the time	Unknown			
SAGPS	Numerous	10m horizontal 95%	1 Hz typical, 10 Hz available			\$200 - \$5,000
Commerical DGPS	OmniStar CSI Receiver	1-3 m horizontal 95%	Depends on receiver. 10 Hz available	9.5"x4.9"x2.0" 2.5 lb., 10 W at 9-16 VDC	4 weeks	~\$5k

Terrain Data Table

Mfg/Product	Type	Resolution	Cost	Format	Area Coverage	Availability	Accuracy	Reference
SRTM C-Band (Pasadena)	Terrain	Level 2 (30m spacing projected)	Cost of reproduction (?)	Unknown	Worldwide	2001	Horizontal 20m Vertical 16m	WGS-84
SRTM X-Band (Germany)	Terrain	Level 2 (30m spacing projected)	Cost of reproduction (?)	16-bit Signed Integer	Worldwide	2001	Horizontal 20m Vertical 4m	WGS-84
Jeppesen AGIT Terrain Data	Terrain/ Obstacle	0.5mi 0.25mi near airports	Unknown		Worldwide	Now	.5m on airport, varies with distance from airport	WGS-84
NIMA DTED-0 (DTED 1, 2 restricted)	Terrain	Level 0 3 arc-sec (100 m) Level 1 1 arc-sec	Free over Internet	Unique format, readable with freeware	Worldwide Level 0, 1 Level 2 is limited to >2% of world's landmass	Now	Horiz 50m 90% RMS circular Vertical 30m 90% RMS Linear Levels 0,1,2 have same accuracy	WGS-84
USGS National Elevation Dataset	Terrain	1 arc-sec latitude by 2 arc-sec longitude	\$45 + \$1 per 7.5-minute quad area. *Free when downloaded	32-bit Integer	US	Now	15m RMSError	Universal Transverse Mercator (UTM) projection

Obstacle Database Table

Mfg/Product	Type	Cost	Format	Area Coverage	Availability	Accuracy
MapTech	Obstacle	\$100	GPS-based navigational parameters provided via NMEA-0183 sentences	collection of around 80,000 United States obstacles and is essential for situation awareness at low altitudes and terminal area navigation.	Now	Unknown
AirspaceUSA	Obstacle	Marketed to Construction-planning firms	Database, continually updated	Includes all 68,000 plus verified and unverified obstacles located in the United States and along the boarder with Canada and Mexico	Now	Unknown
Jeppesen AGIT Terrain Data	Terrain/ Obstacle	Unknown	Unknown	Worldwide	Now	.5m on airport, varies with distance from airport
AODB-IATA	Obstacle	\$650 (one-time, US only)	ASCII Text format CD-ROM	United States	Now	Unspec.
Honeywell	Obstacle	Unknown	Database	more than 70,000 obstacles in most of North America that are 100 feet AGL or more.	Ongoing data collection	
NIMA Airfield Initiative	Obstacle (defined by FARs)	Military	Unknown	1000 Int'l Airports	Now	Unspec.

Head-Mounted Display Table

Mfg/Product	Mono/Binoc	Resolution	Color/BW	Brightness	Weight	FOV	Connection	Cost
Kaiser Comanche Helmet	Binoc	SXGA 1280x1024 AMLCDs (Kopin Corp)	BW See-through	2000 ft-Lamberts	3.9lbs	35V, 52H		\$150,000 est. (current production run is for Sikorsky only, shipping 5/1/02)
Nvision Datavisor 80	Binoc	Multisync up to 1280x1024 1" CRTs	Color See-through	>5 ft-Lamberts	64oz	80V, 120H		\$90,000
ProView SIMEYE XL100	Binoc, (helmet-mounted)	XGA 1024x768	Color See-through	10 ftL	5.0 lbs (incl helmet, optics)	46V,64H (100% overlap)	XGA 15-pin DA	\$74,995
ProView XL 40/50	Binoc (swivel viewers, can be used individ?) Can be mounted to military helmets (HGU-56/P, HGU-33/P, SPH-4B)	1024x768 active matrix TFT	Mono (Green) See-Through	20ftL	28oz	28V, 37H (40, 100% overlap) 49H (50, 25 deg overlap)	15-pin HD-DSUB, female	\$49,995
MicroVision Nomad	Mono Retinal-Scanning	SVGA 800x600	BW (red) See-through	1-480 ft-L	24oz (680g)			\$8000 (Estimated. Avail spr. '01)
Sony LDI-100B	Binoc	LCD SVGA 800x600	Color See-through	Unknown		28H	D-sub 15-pin	\$2100 (discontinued but available)
Virtual I/O Iglasses	Binoc	640x480	Color See-Through	Unknown	8oz			\$580

TekGear M1	Mono	800x600	BW Opaque	20 ft-Lamberts	4oz	16 H	D-sub 15-pin VGA	\$475
Peavey	Panel-Mount	640x480 800x600 1024x768	262,144 Colors	"Sunlight Readable"				

Graphics Board Table

Name	Cost	Pixel/Polygon Rate	Memory	Features	Notes	Benchmark
3Dlabs Oxygen GVX210	\$1225 (mail order)	6.3M/sec	64MB SGRAM	GLint Gamma G2 Geometry Processor	Open GL Direct 3D	AutoCAD2000 c99 v2.1 3DOpenGL benchmark Oxygen GVX210 benchmark score of 41.03 - compared to 33.47 for the Intense 3D Wildcat 4110 Pro, 31.11 for the Elsa Gloria II and 36.51 * 2D Winbench 99 HE 384 (1024x768 true color) * 2D Winbench 99 BG 182 (1024x768 true color) * APC ProE Composite Score 5.48
3dfx Voodoo5 5500	\$299		32MB of DDR SGRAM	3dfx VSA- 100 chip		69.2, 67.5 3D WinBench 2000 scores
ELSA Gladiac	\$329			NVidia GeForce2 GTS chip		90.9 3D WinBench 2000 score
Diamond S3, Inc. Fire GL1 32MB	\$700	4 million polygons /sec	32MB of SGRAM	ATI "Charisma" Engine	Multithreaded and thread safe Open GL ICD support There is no Digital Video Out Connector for digital displays (LCD flat screens).	351 WinMarks on WinBench 99 High-End Graphics AutoCAD2000 c99 v2.1 3DOpenGL benchmark 36.51 for the Diamond Fire GL1
ATI Radeon 32MB DDR	\$279		32MB		Direct X 7 Direct X 8 Open GL Anti- Aliasing supposedly flaky with OpenGL. VGA Connector	94.2 3D WinBench 2000 score
ATI Rage Mobility 128	~\$200		8MB SGRAM		Laptop-Based	Business Winstone benchmark: 35.7
Nvidia GeForce2 GTS	\$200/\$300	25M/sec (?) 800 Mpixels/sec	32/64MB		OpenGL	32MB 3D Winbench 2000: 77.9 34.94 Win NT4
ATI Radeon 64Mb DDR VIVO	\$399 (\$299 for 32MB version)		64MB			ZD Business Graphics Winmark 99: 1,024 x 768, 32- bit color: 332 ZD 3D WinBench 2000: 1,024 x 768 32-bit: 102

Terrain Software Table

Program	Terra Vista (Terrex)	CreatorPro and TerrainPro Tools (Multigen)	World Perfect (VRWP) (MetaVR)	EaSIEST (E&S)	RapidSITE (E&S)	World Builder (AnimaTek)	World Construction Set (3D Nature)	Bryce 4 (Corel)	Blueberry3D
Feature									
Approx. Cost	\$16,900	\$17,500 (includes all of CreatorPro), additional \$17,500 for TerrainPro	\$13,000		\$2,395 RapidSITE Producer, \$5,990 Landscape and Building Creator	\$800	\$940	\$180	\$2,000 for non-realtime, realtime terrain tools and engine “price set through negotiations”
Reads common terrain data formats	DTED, DEM, DFAD, USGS DLG, USGS Land Use	DTED, USGS DEM, .ded	DTED, DEM, and ERDAS, VMAP data	Yes	Yes	Some	Some	Some (limited support)	Some
Only usable with same vendor scene generator	No	No	No (uses MetaVR VRSG, but .flt format is also available)	No	Yes (although there might be unlisted export utilities)	No	No	No (although animation tools are included)	Yes
“Best” output format(s)	.flt, TerraPage	.flt	.flt, .mdx (for VRSG)	.flt,	None	.3ds	.3ds	.obj	None
Outputs multiple levels of detail	Yes	Yes with TerrainPro	Yes	Yes	Probably not	Probably not	Probably not	Probably not	Yes, based on fractals
Originally created for real-time rendering?	Yes	Yes	Yes	Yes	No, but capable of realtime visualization	No	No	No	Yes
Generates custom textures?	No, uses specific textures for each defined			Yes (documentation specifically mentions multiple textures per polygon)		Yes	Yes		Yes
Large scale (>50 mi x 50 mi) terrain	Very good	Good with TerrainPro	Good	Good	OK	Poor	Poor	Poor	Good
Smale scale (<1 mi x 1 mi) terrain	OK	OK	OK	OK	Very Good	Good	Good	Good	Good
Additional features									Fractal-based vegetation and detail texture